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CLAIMS

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1. A method of calibrating a print engine based on a calibration chart having a first plurality of reference colours, the method comprising the steps of
i) printing a test sheet from the print engine; the test sheet having a second plurality of test colours thereon, each test colour corresponding to a reference colour;
ii) digitising the reference and test colours;
iii) calculating a colour difference between corresponding pairs of digitised reference and test colours; and
iv) adjusting the print engine in accordance with the difference to reduce the colour difference between each colour pair, wherein the calibration chart includes openings formed therein, the openings corresponding to the positions of the second plurality of test colours, and the method further comprises the step of:
arranging the calibration chart on the test sheet prior to step (ii).

2. A method according to claim 1, wherein each reference or test colour is formed from a combination of one or more colour components.

3. A method according to claim 1, wherein each reference or test colour is formed from a combination of two or more colour components.

4. A method according to claim 2 or 3, wherein step (ii) further comprises the steps of:

obtaining pixel information representing each digitised test and/or reference colour; and

computing each colour component's intensity at each pixel.

5. A method according to claim 4, further comprising the step of:

averaging the computed intensities to obtain a mean intensity of each colour component for each test and reference colour; and

calculating the difference in mean intensity between corresponding pairs of test and reference colours, the calculated difference being the amount of colour difference between the test and reference colours.

6. A method according to claim 5, wherein the colour difference is defined by a fuzzy variable.

7. A method according to claim 6, wherein the fuzzy variable is represented by:

$$d_i = d(P_i^S, P_i^T) = \frac{1}{k} \times \sum_{x=1}^{k} d^x(P_i^S, P_i^T);$$

where,

d_i is the colour difference between ith pair of corresponding reference colour P_i^S and test colour P_i^T;

k is the number of colour components; and

d^x is the mean colour density difference between the ith pair of corresponding reference colour P_i^S and test colour P_i^T for x colour component.

8. A method according to claim 7, further comprising the step of calculating amount of noise present in each colour pair.

9. A method according to any one of the preceding claims, wherein the colour difference calculation is based on CMYK colour model.

10. A method according to any one of claims 1 to 8, wherein the colour difference calculation is based on RGB colour model.

11. A method according to any one of claims 1 to 8, wherein the colour difference calculation is based on CIEL*A*B*.

12. A method according to any one of the preceding claims, wherein the adjusting step is based on fuzzy inference.

13. A method according to claim 12, wherein the adjustment is automatic.

14. A method according to any one of the preceding claims, further comprising the step of verifying the print engine's output prior to the adjustment step (iv).

15. A method according to claim 14, wherein the verification step provides a user interface to manually adjust the colour difference between corresponding pairs of test and reference colours.

16. A method of calibrating a print engine, comprising the steps of:

(i) capturing an image including a first plurality of reference colours and a second plurality of test colours printed by the print engine, each test colour corresponding to a reference colour;

(ii) digitising the reference and test colours;

(iii) using fuzzy functions to calculate a difference in colour between corresponding pairs of digitised reference and test colours;

(iv) defining the difference as a fuzzy value; and

(v) adjusting the print engine based on the fuzzy value to reduce the colour difference between each colour pair.

17. A method according to claim 16, wherein the reference colours are provided on a calibration chart and the test colours are provided on a separate test sheet prior to the image capture of step (i).

18. A method according to claim 16 or 17, wherein each reference or test colour is formed from a combination of one or more colour components.

19. A method according to claim 18, wherein step (ii) further comprises the steps of:

obtaining pixel information from the digital image; and

computing density of each colour component at each pixel for each test and/or reference colour.

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20. A method according to claim 19, further comprising the steps of: averaging the computed densities to obtain a mean density of each colour component for each test and reference colour; and calculating the colour difference between corresponding pairs of test and reference colours based on respective mean densities.

21. A method according to claim 20, wherein the colour difference is represented by a fuzzy variable , d_i, defined as:

$$d_i = d(P_i^S, P_i^T) = \frac{1}{k} \times \sum_{x=1}^{k} d^x(P_i^S, P_i^T);$$

where,

k is the number of colour components; and

d^x is the mean colour density difference between the ith pair of corresponding reference colour P_i^S and test colour P_i^T for x colour component.

22. A method according to claim 21, further comprising the step of deriving colour channels containing one colour component based on d^x.

23. A method according to claim 22, further comprising the step of calculating a colour difference between colour channels.

24. A method according to claim 23, wherein the colour channel difference is defined as a fuzzy variable, fd_i, where

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$$fd_i = fd(P_i^S, P_i^T) = \frac{1}{m} \times \sum_{x \text{ is a filtered channel}} fd^x(P_i^S, P_i^T)$$

where m is the number of filtered colour channels; and

fd^x is the mean colour density difference between the ith pair of corresponding reference colour P_i^S and test colour P_i^T for x colour component which is a filtered colour channel.

25. A method according to claim 24, further comprising the step of calculating noise ε_i which is defined by:

$$\varepsilon_i = \varepsilon(P_i^S, P_i^T) = d(P_i^S, P_i^T) - fd(P_i^S, P_i^T)$$

26. A method according to any one of claims 16 to 25, further comprising the step of verifying the print engine's output prior to the adjustment step (v).

27. A method according to any one of claims 16 to 26, further comprising the step of: detecting the position of each digitised reference and test colour prior to the calculation step (iii).

28. A method according to claim 16 to 27, further comprising the step of detecting reference marks in the captured image prior to the digitising step (ii).

29. A method according to claim 28, further comprising the step of comparing the position of the reference marks with default position values of the reference marks;

calculating the difference; and

locating the positions of each reference and test colour in the captured image to perform the digitisation step.

30. A method of deriving an adjustment value for a print engine, the method comprising the steps of:

(i) capturing an image including a first plurality of reference colours and a second plurality of test colours printed by the print engine, each test colour corresponding to a reference colour;

(ii) digitising the reference and test colours;

(iii) calculating a difference in colour between corresponding pairs of digitised reference and test colours; and

(iv) providing the calculated colour difference for verification.

31. A method according to claim 30, wherein step (iv) further comprises the step of displaying the colour difference.

32. A method according to claim 31, wherein the colour difference is displayed in graphical form.

33. A method according to any one of claims 30 to 32, further comprising the step of adjusting the print engine based on the calculated difference to reduce the colour difference between each colour pair.

34. A method according to claim 33, wherein the adjustment step is performed before step (iv).

35. A method according to claim 33, wherein the adjustment step is performed after step (iv).

36. A method according to claim 34, further comprising the steps of:
printing a test sheet including the plurality of test colours from the adjusted print engine; and
visually comparing the test colours against a plurality of reference colours provided on a calibration chart.

37. Apparatus for calibrating a print engine based on a calibration chart having openings formed therein and a first plurality of reference colours, the apparatus comprising:
i) a print engine arranged to print a test sheet having a second plurality of test colours, each test colour corresponding to a reference colour and the positions of the second plurality of test colours corresponding to the openings of the calibration chart when the chart is arranged on the test sheet;
ii) means for digitising the reference and test colours;
iii) processing means for calculating a colour difference between corresponding pairs of digitised reference and test colours; and
iv) control means for adjusting the print engine in accordance with the difference to reduce the colour difference between each colour pair.

38. Apparatus for calibrating a print engine comprising:

(i) an image capturing device arranged to capture an image including a first plurality of reference colours and a second plurality of test colours printed by the print engine, each test colour corresponding to a reference colour;

ii) means for digitising the reference and test colours;

(iii) processing means for calculating a difference in colour between corresponding pairs of digitised reference and test colours using fuzzy functions;

(iv) processing means for defining the difference as a fuzzy value; and

(v) control means for adjusting the print engine based on the fuzzy value to reduce the colour difference between each colour pair.

39. Apparatus for deriving an adjustment value for a print engine comprising:

(i) an image capturing device arranged to capture an image including a first plurality of reference colours and a second plurality of test colours printed by the print engine, each test colour corresponding to a reference colour;

ii) means for digitising the reference and test colours;

(iii) processing means for calculating a difference in colour between corresponding pairs of digitised reference and test colours; and

(iv) verification means for checking the calculated colour difference.

40. Apparatus according to claim 39, further comprising a display.

41. Apparatus according to claim 39 or 40, further comprising control means for adjusting the print engine based on the calculated difference to reduce the colour difference between each colour pair.

42. Calibration apparatus according to claim 41, further comprising input devices to control the control means.